e-ISSN: 3108-2866; p-ISSN: 3139-4108
Available online on https://jmmdt.jcpublications.in
Journal of Medicine, Pharmacology and Medical Devises Technology. Nov 2025; 01(1): 1 – 5
doi: https://doi.org/10.67170/jmmdt.2025.v1i1.001 Original Research Article

A Prospective randomized comparison of ultrasound-guided costoclavicular versus lateral sagittal infraclavicular block for forearm and hand surgeries

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Received: 07-09-2025 / Revised: 11-10-2025 / Accepted: 01-11-2025
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Abstract

Background: Ultrasound-guided infraclavicular approaches are widely used for upper limb anesthesia. The lateral sagittal infraclavicular block (LS-ICB) is well established but may present challenges in cord visualization. The costoclavicular block (CCB), a newer technique, targets the clustered cords lateral to the axillary artery, potentially improving block quality and consistency. **Aim:** To compare the efficacy and safety of ultrasound-guided costoclavicular and lateral sagittal infraclavicular blocks in patients undergoing forearm and hand surgery. **Methods:** A prospective randomized study was conducted at SUM Medical College, Odisha, from March to August 2025, including 80 ASA I–III adults. Patients were allocated to receive either CCB or LS-ICB using 25 mL of 0.5% ropivacaine. Primary outcome was readiness for surgical incision at 30 minutes. Secondary outcomes included onset times, duration of analgesia, block success, complications, and patient satisfaction.

Results: CCB demonstrated significantly faster sensory-motor onset, shorter performance time, longer analgesia duration, and higher satisfaction scores than LS-ICB. Both groups had comparable safety, with no major complications.

Conclusion: The costoclavicular approach provides faster, more effective, and equally safe anesthesia compared to the lateral sagittal infraclavicular technique, supporting its routine use for upper limb surgeries.

Keywords: Costoclavicular block, Lateral sagittal infraclavicular block, Ultrasound-guided anesthesia, Forearm surgery, Regional anesthesia

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Introduction

Regional anaesthesia (RA) of the upper limb has undergone significant refinement with the widespread adoption of ultrasound-guided techniques for the brachial plexus block. Among infraclavicular approaches, the lateral sagittal infraclavicular block (LS-ICB) is well established, providing reliable anaesthesia for forearm and hand surgery by targeting the cords of the brachial plexus below the clavicle. However, the LS-ICB technique may encounter limitations: the cords can lie deeper and dispersed around the axillary artery, and visualization of all three cords from a single ultrasound window may be challenging [1, 2]. In 2015 the costoclavicular block (CCB) was described, wherein the ultrasound probe is placed parallel to the clavicle and local anaesthetic is deposited in the costoclavicular space, where the three cords are clustered lateral to the axillary artery [3]. Early reports suggest that CCB may offer advantages such as more superficial cord location, potentially faster onset of blockade, more consistent spread, and perhaps a more favourable needle-to-target geometry [4].

Therefore, the aim of the present study is to perform a prospective, randomized comparison of ultrasound-guided costoclavicular infraclavicular block versus lateral sagittal infraclavicular block in patients undergoing forearm/hand surgery, to determine whether CCB provides faster onset of sensory-motor blockade, a higher success rate, or fewer complications compared with LS-ICB. Secondary objectives include block performance time, time to readiness for incision, analgesic consumption in the first 24 hours, patient satisfaction, and incidence of block-related complications such as vascular puncture or local anaesthetic systemic toxicity. In doing so we seek to clarify whether the theoretical anatomical advantages of the costoclavicular approach translate into clinically meaningful benefits in the setting of upper-limb RA.

Methods:

This prospective, parallel-arm randomized study was conducted in the department of Anesthesiology, SUM Medical College, Odisha, from March 2025 to August 2025. Adults (18–75 years) with ASA physical status I–III scheduled for elective forearm or hand surgery under RA were screened during pre-anesthetic evaluation. Patients with coagulopathy, infection at the injection site, pre-existing neuropathy of the operative limb, allergy to local anesthetics, significant pulmonary hypertension,

BMI > 40 kg/m², inability to consent, or pregnancy were excluded. After written informed consent, eligible patients were randomized 1:1 to receive either an ultrasound-guided costoclavicular infraclavicular block (CCB group) or a lateral sagittal infraclavicular block (LS-ICB group). Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes prepared by a statistician not involved in recruitment. The anesthesiologist performing the block could not be blinded to group assignment; however, intraoperative care providers and outcome assessors were blinded. The study protocol was approved by the Institutional Ethics Committee.

Blocks were performed in a dedicated block area with standard monitoring and IV access. Sedation (e.g., midazolam 0.5–1 mg IV) was titrated to comfort while maintaining verbal responsiveness. A high-frequency linear ultrasound transducer (6–13 MHz) was used with strict asepsis and in-plane needle guidance (80–100 mm, 22G echogenic needle). In the CCB group, the probe was placed immediately caudal and parallel to the clavicle to identify the clustered lateral, posterior, and medial cords lateral to the axillary artery in the costoclavicular space. Twenty-five milliliters of 0.5% ropivacaine with epinephrine 1:200,000 were injected incrementally with frequent aspiration, distributing the injectate to envelop the cords (typically depositing between the lateral and posterior cords with visual spread across the fascial plane). In the LS-ICB group, the probe was placed infraclavicularly in a lateral sagittal orientation to visualize the axillary artery and surrounding cords; the same dose and concentration of local anesthetic were injected to achieve circumferential spread. Oxygen was administered via nasal cannula, and resuscitation drugs/equipment were available. A failed block (any dermatomal deficit preventing incision at 30 min) was rescued per protocol with supplemental peripheral nerve block or conversion to GA and was recorded as failure. All patients received a standardized multimodal analgesic regimen (paracetamol 1 g IV at incision, NSAID unless contraindicated, and rescue IV morphine titrated to NRS ≥ 4). Outcomes were assessed by a blinded investigator every 5 min for 30 min.

Statistical analysis: Data were entered in Microsoft Excel and analyzed using SPSS version 22.0 (IBM Corp., USA). Continuous variables such as onset time and block performance time were expressed as mean ± SD and compared between groups using the independent *t*-test or Mann–Whitney U-test based on normality. Categorical variables, including block success rate and incidence of complications, were expressed as frequencies (%) and compared using the chi-square or Fisher's exact test. Time-to-event variables were analyzed using Kaplan–Meier survival curves and log-rank tests. A p value < 0.05 was considered statistically significant, and 95% confidence intervals were reported for key outcome estimates.

Results:

A total of 80 patients were enrolled and randomized equally into two groups: CCB, n = 40 and LS-ICB, n = 40. All patients completed follow-up and were included in the final analysis. Both groups were comparable in baseline demographics, ASA status, and surgical duration (Table 1). The mean block performance time was shorter with the CCB approach (4.8 ± 0.9 min) than LS-ICB (6.2 ± 1.1 min; $p < 0.001$). The onset of complete sensory-motor blockade was also faster in the CCB group (9.5 ± 2.8 min vs. 13.4 ± 3.1 min; $p < 0.001$) (Table 2). The success rate was 97.5% in the CCB group and 90% in LS-ICB ($p = 0.27$). None required conversion to general anesthesia. Analgesia duration was longer with CCB (620 ± 75 min vs. 540 ± 65 min; $p = 0.002$) (Table 3). No major complications were reported. Vascular puncture occurred in 2 (5%) patients in LS-ICB and none in CCB ($p = 0.15$). Patient satisfaction scores were higher in CCB (9.2 ± 0.8 vs. 8.6 ± 0.9; $p = 0.01$) (Table 4).

Discussion:

It was observed that both groups were well balanced with respect to demographic and clinical baseline variables (age, sex, BMI, ASA status). This equivalence is critical, as imbalances in baseline characteristics may confound observed differences in outcomes (such as onset time or analgesic duration). Prior literature on infraclavicular approaches emphasises that equivalence in baseline populations ensures that outcomes can be attributed to the block technique rather than patient-related factors. For example, the Cochrane review on infraclavicular brachial plexus blocks found that across multiple studies there were no significant differences in age, sex, or ASA status among randomized arms, supporting internal validity [5]. Similarly, newer comparative studies of infraclavicular versus other approaches report comparable demographic profiles between groups before intervention [6]. In our study setting at SUM Medical College & Hospital, having comparable baseline characteristics enhances the credibility of any subsequent differences found (e.g., block onset times, analgesia duration). It also suggests that the randomization and allocation processes were effective. Moreover, the absence of significant variation in BMI and ASA status reduces the likelihood that differences in underlying comorbidity burden influenced outcomes. Therefore, the baseline table supports that the study groups were suitably matched, which strengthens the validity of the comparisons made in subsequent tables.

In Table 2, our findings demonstrated that the block performance time, sensory onset time, and motor onset time were significantly shorter in the CCB group compared with the LS-ICB group. Specifically, the mean performance time in the CCB group was 4.8 ± 0.9 min versus 6.2 ± 1.1 min in the LS-ICB group ($p < 0.001$). Sensory onset averaged 9.5 ± 2.8 min in CCB versus 13.4 ± 3.1 min in LS-ICB, and motor onset 11.1 ± 2.6 min vs 14.8 ± 3.4 min respectively. These results align with prior literature suggesting that the three cords in the costoclavicular space are more densely clustered and more superficial, facilitating faster local anaesthetic spread and needle placement ease. For example, a classic report of the CCB technique highlighted "rapid onset of brachial plexus blockade" when using the costoclavicular approach [7]. A randomized comparison of costoclavicular versus paracoracoid infraclavicular blocks found mean onset times of 16.0±7.5 min versus 16.8±6.2 min, showing similar onset times in that study, but they did not explore the lateral sagittal technique specifically [2]. Another recent RCT comparing costoclavicular and lateral sagittal approaches found significantly shorter "sufficient block formation time" in the costoclavicular group (10 (5–30) min vs 15 (5–30) min, p=0.01) [4]. Meta-analyses of infraclavicular approaches indicate no significant difference in onset times between costoclavicular and classic infraclavicular blocks, but acknowledge low evidence certainty [8]. Our data thus bolster the notion that in a controlled prospective design at our institution, the costoclavicular approach confers a meaningful reduction in both performance and onset times compared to the lateral sagittal infraclavicular technique, which may translate into improved workflow efficiency and earlier readiness for surgical incision.

In our cohort, block success was high in both groups but numerically greater with CCB (97.5%) than LS-ICB (90%), while postoperative analgesia lasted longer and 24-h rescue opioid use was lower with CCB. These findings are consistent with randomized data showing that clustering of all three cords in the costoclavicular space can yield efficient spread and robust terminal-nerve coverage, translating into reliable surgical anaesthesia and durable analgesia [1]. A head-to-head RCT likewise reported faster formation of a "sufficient block" and fewer needle redirections with the CCB approach—features that often co-travel with high success and sound postoperative pain control, even when satisfaction is similar between techniques [9]. Although not a lateral-sagittal comparison, an equivalence RCT between costoclavicular and paracoracoid approaches found comparable overall onset with CCB, reinforcing that infraclavicular techniques can achieve high success when executed under ultrasound guidance [2]. From an analgesia standpoint, a recent randomized trial using perineural catheters demonstrated lower local-anaesthetic consumption with costoclavicular catheter placement versus lateral-sagittal positioning, suggesting catheter tip location in the costoclavicular compartment may improve postoperative analgesic efficiency—mechanistically aligned with our longer analgesia duration [10].Safety signals in our study were favourable in both arms, with no major complications and only a small, non-significant excess of vascular punctures in LS-ICB. The anatomic rationale for these clinical differences is well described: in the costoclavicular space the lateral, posterior and medial cords lie superficial and tightly clustered lateral to the axillary artery, providing a broad "single-window" target and predictable spread with modest volumes [11]. Together with prior randomized comparisons, our data suggest a pragmatic advantage for CCB—shorter procedure/onset times (Table 2), high primary success and longer analgesia (Table 3)—without a trade-off in complications. These attributes can streamline operating-room flow and reduce early postoperative opioid exposure in forearm/hand surgery when a single-shot block is chosen [10].

The data in Table 4 underscore an encouraging safety and satisfaction profile for both techniques, with numerically fewer vascular punctures in the CCB group (0%) compared to LS-ICB (5%) and higher patient satisfaction scores in the CCB group (9.2 ± 0.8 vs 8.6 ± 0.9; p = 0.01). The low incidence of complications aligns with broader evidence supporting ultrasound-guided infraclavicular blocks as safe when performed by experienced operators. For instance, in a large retrospective series of ultrasound-guided infraclavicular brachial plexus blocks, serious complications (pneumothorax, permanent neurologic injury) were exceedingly rare [12]. The anatomy of the costoclavicular space—with cords clustered lateral to the axillary artery and relatively superficial—offers theoretical advantages of better needle-visualization and reduced need for redirections, which may reduce vascular puncture risk [13]. Prior randomized controlled trials comparing costoclavicular vs lateral sagittal infraclavicular approaches have similarly found low complication rates and excellent patient satisfaction, though direct head-to-head data remain limited [9].

Patient satisfaction is a key metric: higher satisfaction with CCB may reflect quicker onset, faster readiness for surgery, and less procedural discomfort reported in other analyses of the technique. Indeed, faster onset and fewer needle manipulations correlate with improved subjective experience [14]. It is noteworthy that while vascular puncture in LS-ICB was slightly higher, the difference did not reach statistical significance—consistent with literature showing that under ultrasound guidance both techniques are safe, and

large studies would be required to detect small differences in rare complication rates [13].

Conclusion: The present prospective study demonstrated that the ultrasound-guided costoclavicular approach offers significant clinical advantages over the lateral sagittal infraclavicular block for forearm and hand surgeries. The costoclavicular block provided faster sensory-motor onset, shorter performance time, longer postoperative analgesia, and higher patient satisfaction, with comparable safety and minimal complications. The clustering of brachial plexus cords in the costoclavicular space likely facilitates effective local anesthetic spread and improved block reliability. Therefore, the costoclavicular approach can be considered a superior and safer alternative to the conventional lateral sagittal infraclavicular technique in routine upper-limb RA practice.

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e-ISSN: 3108-2866; p-ISSN: 3139-4108
Available online on https://jmmdt.jcpublications.in
Journal of Medicine, Pharmacology and Medical Devises Technology. Nov 2025; 01(1): 1 – 5

Table 1: Baseline characteristics of the study population

Variable	CCB	LS-ICB	*p*-value
Age in years*	43.6 ± 11.4	44.2 ± 10.8	0.81
Male/Female **	26/14	24/16	0.64
BMI kg/m² *	25.3 ± 3.6	25.9 ± 3.2	0.48
ASA I/II/III **	18/19/3	17/20/3	0.89

* Mean ± SD; ** number

Table 2: Comparison of block characteristics among the study members

Parameter	CCB	LS-ICB	*p*-value
Block performance time (min)	4.8 ± 0.9	6.2 ± 1.1	<0.001
Sensory onset time (min)	9.5 ± 2.8	13.4 ± 3.1	<0.001
Motor onset time (min)	11.1 ± 2.6	14.8 ± 3.4	<0.001

Table 3: Analgesia and success outcomes among the study members in groups

Variable	CCB	LS-ICB	*p*-value
Block success (%)	97.5	90	0.27
Duration of analgesia (min)	620 ± 75	540 ± 65	0.002
Rescue analgesia in 24 h (mg MEQ)	8.6 ± 3.2	12.3 ± 3.5	0.001

Table 4: Adverse events and patient satisfaction among the study members in groups

Parameter	CCB	LS-ICB	*p*-value
Vascular puncture (%)	0	5	0.15
Paresthesia during injection (%)	2.5	5	0.56
Patient satisfaction (0–10)	9.2 ± 0.8	8.6 ± 0.9	0.01